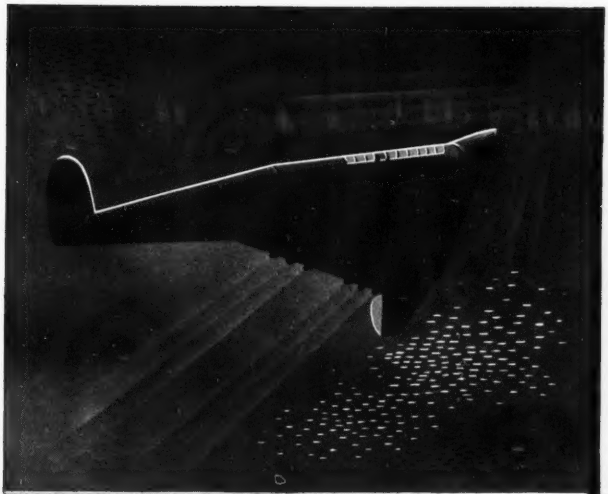
THE CORNELL ENGINEER

COLLEGE OF ENGINEERING · CORNELL UNIVERSITY



Oh say can you see-

"That's Jonesey—putting out his flag again.

"He hasn't missed one Sunday in the eight years we've been neighbors. I used to kid him about it a lot. Asked him why didn't he buy a cannon to shoot off with it. He took it good-natured-like. But we got to talking last week about war in general. That was the first time I even knew he had a son.

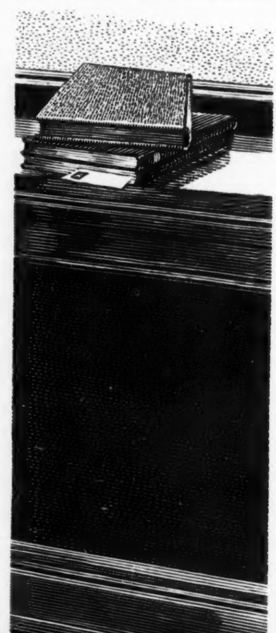
"His boy, Joe, enlisted right after Pearl Harbor and got overseas fast. When young Joe came back, Jonesey met him at the railroad station, stayed up with him all night and rode out with him to the cemetery on the hill. After it was all over, the sergeant gave Jonesey the flag that had covered Joe. *That's it over there.* I don't kid Jonesey any more.

"Instead, I've been listening respectfully when he talks about the flag . . . only when *he* says it, it's Flag. With a capital F. Same capital F he puts on Freedom, which is what he really means. Jonesey sure made me think about Freedom a lot. For instance . . .

"When I vote, nobody knows where I put my X's. Nobody puts me in jail for picking out my own church. And no teachers tell my kids to spy on me and turn me in because I squawk about taxes or high prices. And when I told my boss I was quitting to open a little grocery with the dough I'd saved in war bonds, he wished me luck and said he'd have his missus buy their groceries from me.

"*That's* what Jonesey meant when he said our Freedom is right under our noses. Can't feel it or see it. But it's there just the same, wrapped up in every star and stripe in that Flag across the street.

"And, if you'll excuse me, I'm going outside and hoist *my own* Flag, too . . . just bought it last night. 'Oh say can you see?' *I sure can . . . now!*"



REPUBLIC STEEL

Republic Building, Cleveland 1, Ohio

Republic BECAME strong in a strong and free America. Republic can REMAIN strong only in an America that remains strong and free . . . an America who owes much of her prosperity to her many huge industries that provide her people with the world's finest living. *Through these many industries, Republic serves all America.* A typical example can be found in the Petroleum Industry whose products furnish much of the nation's power, heat and light. In this production, too, steel plays a vital role . . . carbon, alloy and stainless . . . much of which comes from the many mills of Republic.

* * *

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Founded 1885

The CORNELL ENGINEER

Volume 16 May, 1951 Number 8

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Cover: Testing a Z-section beam in a transverse test.

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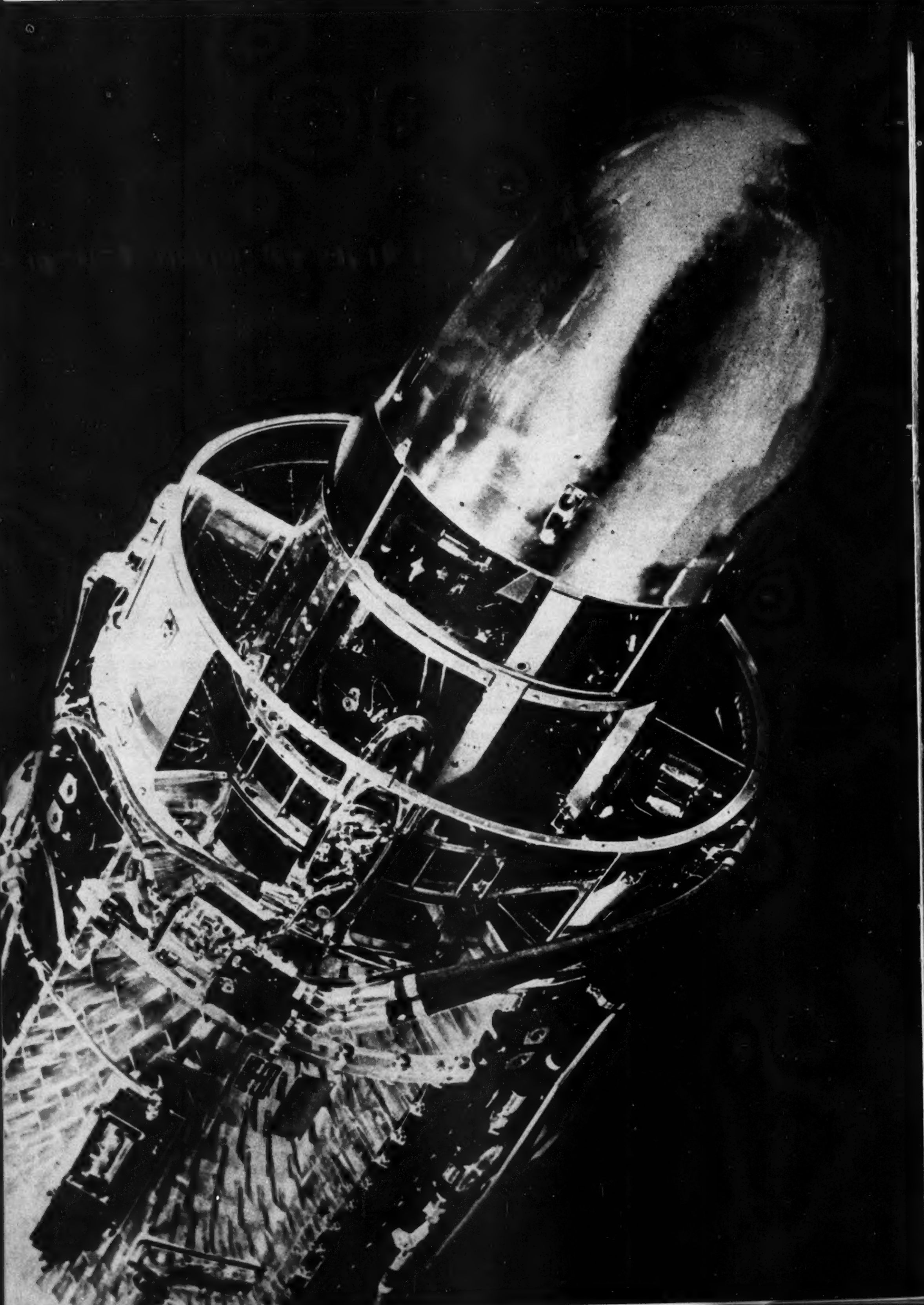


Turboprop Engines

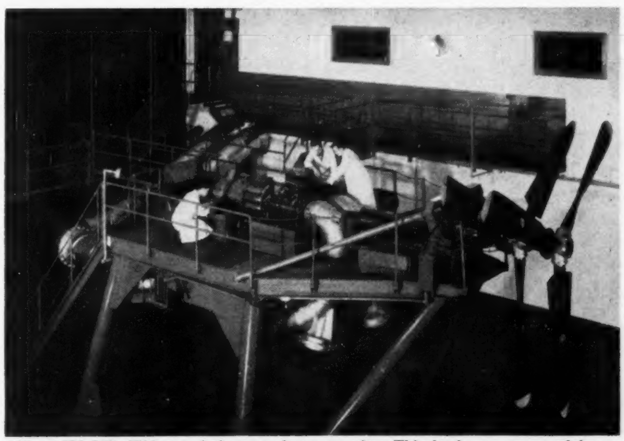
By DR. P. F. MARTINUZZI

HIGHER EFFICIENCY SHOWS BRIGHT FUTURE

Since the end of the war, gas turbines have taken a pre-eminent place in aviation under the form of jet engines. Applied at first to fast fighters, turbojets soon showed such favorable features that their use has been extended to all fighters and to many fast bombers. This rapid success has been due to many concomitant causes; extremely light weight and very large power output are easily obtained; maintenance is much simplified; operation at all altitudes is easy and does not require special superchargers; there is no propeller and consequently no loss of power due to it, no torque reaction and the landing-gear can be made short and light.

Recently another type of aircraft gas turbine, the turboprop, has gained considerable publicity. The first production models have already been built and it is likely that in the next few years the turboprop will find a wide field of application both in military and in commercial aviation. The reasons that have lead to the development of the turboprop will best be understood if turbojet and turboprop are compared.

A turbojet consists essentially of an air-intake, an air-compressor, a combustion chamber, a turbine and an exhaust pipe or cone. The compressor can handle very large quantities of air (from 50 to 150 lbs. of air per second) and raise its pressure from atmospheric to 4 or 5 times atmospheric pressure. This high-pressure air enters the combustion chamber (which in practice often consists of many small chambers working in parallel) where an appropriate amount of liquid fuel is continuously burned in the air so that the combustion gases reach a maximum temperature of over 1600°F; owing to the high temperature, the volume of the combustion products is very much larger than that of the air entering the combustion chambers, while the pressure remains substantially the same. These hot high-pressure gases expand partly in the turbine, where they generate just enough power to drive the compressor. The gases leave the turbine at a pressure higher than atmospheric and at high velocity, and the remaining excess of pressure further increases this velocity in the exhaust cone which acts as a nozzle. The whole machine is so mounted on the aircraft that the gases come out of the exhaust cone in the opposite direction from the direction of flight. Turbine and compressor have no external connection and there is no power output; the whole machine has the purpose of providing a large stream of fast exhaust gases. The acceleration of a large mass of gas in the machine causes a force to be applied to the machine in the direction of flight, just as the acceleration of a bullet in a rifle causes the gun to recoil. This force is called thrust and is directly applied to the frame of the aircraft so that it is utilized 100% without any loss in passing from turbojet to the aircraft, whereas a piston engine or a turboprop converts its power into thrust by means of the propeller, and in this conversion considerable losses are incurred (from 20 to 40%).

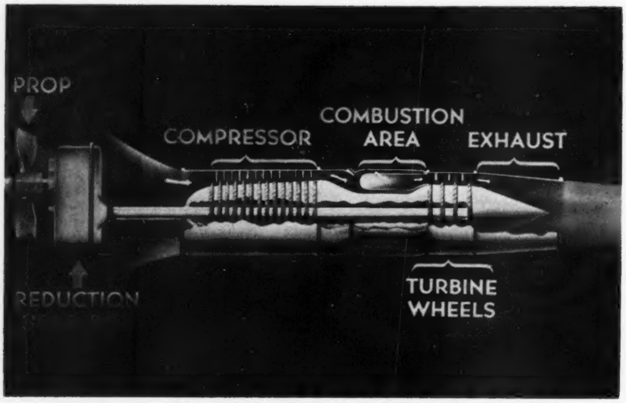


Allison 550 HP, 2500 pound thrust turboprop engine. This is the most powerful propeller type engine cleared for flight, and was developed for the Navy.

By means of some simplifying assumptions it is easy to calculate the thrust; if the air is assumed to enter the compressor with a velocity u equal to the velocity of flight and if the exhaust gases leave the exhaust cone with a velocity w much larger than u, neglecting the weight of the fuel, the thrust for each lb.

Phantom view of the nose of a turboprop engine. These engines promise to eventually replace the present jet engines because of their greater operational flexibility.

—Allison



Cross section of a turboprop engine.

of air that flows through the machine will be equal to the change of momentum of this lb. of air, that is

$$T = 1/g\ (w-u).$$

In modern jets, w is generally slightly over 2000 fps. If we assume a speed of flight of 600 mph, which corresponds to 880 fps, and if w is 2080 fps, it can easily be seen that there is a thrust of 37.5 lbs. per lb. of air; so that a jet having a flow of 100 lbs. of air per second would give a thrust of 3750 lbs. The power developed equals velocity multiplied by thrust; converting the units, the result is 6000 HP. Modern jets weight about .5 lb. per lb. of thrust; their specific fuel consumption is 1 lb. of fuel per HP/hr. Consequently the jet will weigh about .3 lb/HP, which is excellent, and the consumption will be .625 lbs/HP/hr, which is higher than that of a piston engine (less than .5 lb/HP/hr) but not prohibitive. If, however, the same jet is fitted to another aircraft having a maximum speed of 450 mph, or 660 fps, then the power developed is only 4500 HP, assuming that the maximum thrust of the jet remains unchanged. In this case, the weight per HP becames .42 lb, still good, but the fuel consumption rises to .83lb/HP/h, very high indeed. If the same jet were fitted to an aircraft having a maximum speed of 300 mph, the power developed would be only 3000 HP, the specific weight would be over .6 lb/HP and the fuel consumption would become 1.25 lb/HP/hr. This last figure is much too high and would render the use of the jet in this case quite impractical.

From the above examples it can be seen that a jet is not an engine in the ordinary sense of the word, because it does not give power; it only gives thrust and the power obtained depends on the speed of the aircraft. The modern jet engine can in practice be applied only to aircraft flying at high speeds of over 450 mph; the higher the speed the better become both specific weight and specific fuel consumption. If the speed is extremely high, well in the supersonic range, then the jet becomes again unsuitable and special engines of the ram-jet type must be used.

The turbojet has another disadvantage; as the maximum thrust is almost constant, the power developed at low speed is low; consequently, jet aircraft have a slow take-off and require long runways. This is particularly serious for aircraft that must take off from carriers. Recent developments have permitted an increase of thrust at take-off by means of after-burning (burning fuel in the tail pipe after the turbine, and so increasing the exhaust speed) or other auxiliary devices. But these stop-gap methods complicate the jet engine and are terribly wasteful of fuel .

The turboprop engine promises to bring some of the advantages of the jet engine to aircraft flying at relatively low speeds (300/500

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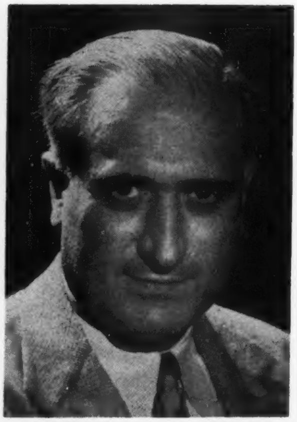
THE AUTHOR



Professor P. F. Martinuzzi

Dr. P. F. Martinuzzi, Professor of Mechanical Engineering, is a gas turbine and internal combustion engine specialist. He studied in Italy, at the University of Padua and at the School of Engineering in Turin, where he obtained his degree of Doctor in Mechanical Engineering in 1923. He became a designer of automotive and aircraft engines; in 1929 he left Italy and worked in England, France and Switzerland. He was engaged from the beginning of his career in problems of supercharging, and this led naturally to his interest in the new field of gas turbines; from 1938 he started work on gas turbines and compound engines (a combination of high-supercharged piston engines and gas turbines). In 1946 he returned to Italy and became head of the gas turbine section at the Italian National Research Council in Rome. He came to Cornell in 1949.

COMBINES PROPERTIES OF CAST IRON AND STEEL

Nodular Cast Iron

By ALFRED BLUMSTEIN, EP '51

Hailed by many as the most important new development in the cast iron field since the invention of malleable iron in 1820, nodular cast iron has been causing quite a spurt of activity and interest in metallurgical circles for the past three years. This is a material whose value lies in its combination of many of the process advantages of grey cast iron with many of the property advantages of steel—truly a desirable grouping.

Private research on the problem of developing such a material had been going on for several years when, in March of 1948, Messrs. Morrogh and Williams of the British Cast Iron Research Association published a paper announcing the achievement of such an objective. Immediately thereafter, in May, 1948, the International Nickel Company, which had simultaneously been working towards the same goal, made public a similar material which they named "ductile cast iron." INCO holds the patent on this material, and it is their version that is being commercially produced at present.

There is still much research to be done in ironing out the kinks in the production of the material and in determining its properties and its applications. A sizeable contribution toward that end is being made right here at Cornell as a senior project under Professor Joseph O. Jeffrey of the Department of Engineering Materials. Investigations here are concerned with impact resistance, notch sensitivity, machinability, damping capacity, and torsion and fatigue properties. The intention is to evaluate nodular cast iron on its own and as compared to other ferrous materials. Results of the research are to be announced at the May 15 meeting of the Southern Tier Chapter of the American Society for Metals in Waverly, N. Y.

The seven members of the research group. From left to right they are Bill Johenning, Professor Joseph Jeffries, Bill Cowley, Al Blumstein, Walt Crone, Tom Poyer, and Bill Jennings.

The mechanical properties of nodular cast iron may best be discussed on the basis of microstructure. As can be seen from the accompanying photomicrographs, the major difference between nodular iron and grey cast iron lies in the distribution of the carbon, which appears as graphite. In the grey iron, the graphite exists as long flakes. Since the mechanical strength of graphite is virtually nil, the flakes have the effect of voids or notches in the metallic matrix. As a result of the long thin shape of the flakes, there is a large degree of iron-carbon contact, and the effect of the graphite is comparatively

large. This has the same effect as that caused by many small cracks throughout the piece, and results in high stress concentrations, accounting for the characteristic brittleness of the grey cast iron, and its low strength.

Metallurgical Goal

It has long been the goal of metallurgists to minimize the effect of the graphite in the cast iron without eliminating it. This is accomplished by clumping the graphite instead of letting its spread out as flakes. The theoretical ideal would be to have the graphite distributed as minute spheroidal specks in the iron matrix. This brings the carbon-iron interface to a minimum and reduces the stress concentrations.

Previous to the invention of nodular iron, the only means for approaching this ideal was by the malleablizing process invented 120 years ago by Boyden. By heating white cast iron (in which the carbon is combined as iron-carbide) for about fifty hours, the unstable carbide decomposes, leaving small patches of graphite in the iron. The big drawback to this process is the long, expensive heat-treatment required. Furthermore, the process may only be used for small castings, since it is only in such cases that the required carbide structure may be achieved.

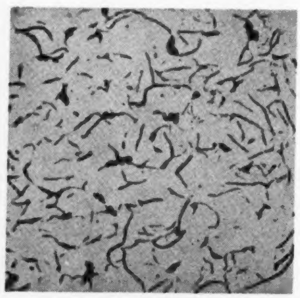
Innoculant Added

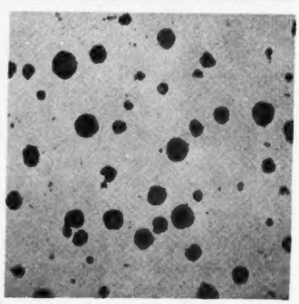
Nodular cast iron is the latest advance in this attempt to "spherize" the graphite in cast iron. The process consists of the addition of certain carbide-stabilizing agents, such as magnesium or cerium, to the molten grey iron. This is followed by the introduction of a ferro-silicon inoculant which overcomes the tendency just induced to form carbides, and causes the graphite to precipitate as nodules. The first effect of the carbide-former is to reduce the sulphur content to about .02 per cent, after which it gets to work on the graphite. The more of the nodulizing agent present, the more of the graphite that will precipitate as nodules instead of flakes. When the point has been reached when all the graphite precipitates as nodules, however, the excess of the agent starts to work in forming carbides with graphite. This, too, is understandable, since it results in brittleness. Thus, it is seen that the amount of nodulizing agent added is rather critical and must be controlled within close limits.

The British process for making what they termed "spherulitic graphitic cast iron," first published in the March, 1948 issue of the *Journal* of the Iron and Steel Institute, made use of cerium as the nodulizing agent. They were restricted by this material in that their irons had to be hyper-eutectic (having a carbon equivalent greater than 4.3%). A big commercial drawback to their process was the cost of the cerium addition—about $30 per ton of iron—as compared with $20 for the magnesium process now in use in this country.

Magnesium Used

The metallurgists of the International Nickel Company, largely through the work of Albert Gagnebin, developed the more commercially satisfactory product using magnesium as the nodulizing ingredient. The first major difficulty that presented itself was prevention of the violent reaction of the magnesium upon coming in contact with the molten iron. Since pure magnesium boils at about 2030°F., its contact with the iron at about 2600°F. would tend to produce rather disastrous results. This is presently being remedied by making the addition as a magnesium-nickel alloy, thus diluting the magnesium and raising its boiling point. The only difficulty in this respect now is the necessity for shielding the eyes from the flash, but there is no longer the problem of metal being blown from the mold.





Top: **Gray cast iron. The structure is greatly interrupted by the flaky form of the graphite.**

Bottom: **Nodular cast iron. The graphite is more compact when spheroidal, making the structure more continuous.**

Temporary Specifications

Temporary specifications for nodular cast iron have recently been written by the International Nickel Company. They have classified the production into four grades designated on the basis of properties. The specifications consist of six numbers of the form "xx-yy-zz." The "xx" indicates the minimum tensile strength; the "yy" specifies the minimum yield strength; and the zz represents the minimum elongation, in percent. The strengths are in thousands of pounds per square inch (psi).

The 90-65-02 grade, with a pearlitic matrix in the as-cast condition, is used where high strength and wear resistance is requisite. Its average tensile strength is about 100,000 psi, and its elongation will vary between 2 and 5 per cent.

A tougher as-cast grade is the 80-60-05. This exhibits a pearlitic-ferritic matrix, and has an elongation range of from 5 to 10 per cent.

Ductility Achieved

By giving either of these grades a relatively short annealing treatment, much greater ductility is obtained as a consequence of the completely ferritic matrix that is formed. This grade—the 60-45-15—exhibits an elongation of 17 to 23 per cent, comparable with that of carbon steel.

For some applications, there is a fourth grade, specified as 80-60-00, which allows more phosphorous and, in general, requires less control. Its main use would be in instances where strength is necessary, but ductility is not of too

(*Continued on page* 32)

Lincoln Hall Clock

By DAVID SCHERAGA, EE '54

Aside from those who are awakened at the end of each hour, most engineers pay little or no attention to the bells which are responsible for running classes on schedule. These bells, as so many other small things which are taken for granted in the course of our everyday lives, actually do serve an important purpose merely by helping to run things in an orderly and efficient manner in the various engineering buildings.

In order to function properly with split-second coordination, you would naturally expect them to be run by a complex, electronic mechanism, as is usually the case these days. Yet, the entire system, centers about a rather unobtrusive looking grandfather type clock located in room 113 of Lincoln Hall. Upon closer examination though, we would notice that this clock contains a series of neatly arranged switches and electric relays located behind the pendulum. It is this relatively simple arrangement which has kept Cornell engineers on time for the past thirty-five years.

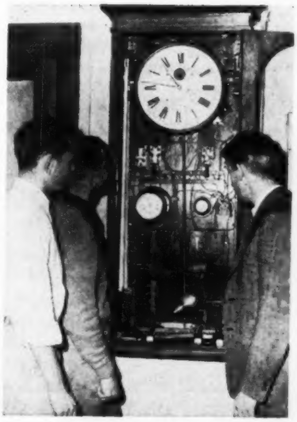
The clock, a product of E. Howard and Co. of Boston, was installed in 1914 when the Departments of Civil Engineering and Astronomy were both located in Lincoln Hall. In fact, one of its first functions was to aid the Cornell astronomers in their time observations. Originally it served not only the engineering buildings, but also a good deal of what was then Cornell including Roberts Hall on the Ag campus. In addition, it was first designed to perform the double duty of running both clocks and bells; however, it now controlls only those clocks located in Lincoln Hall.

Throughout the years Professor Underwood has had charge of the clock, making sure that it ran smoothly and accurately. Since his retirement though, Professor McNair has assumed his duties which include timing it each month by means of a shortwave radio signal and arrangement of any changes or additions in the bell schedule.

The method by which the bells are rung is actually very simple. The clock contains two tapes, each of which revolves on a pair of circular metal discs similar to a belt and pulley system. Each tape is capable of carrying two different bell schedules which means that the clock as a whole can carry four. A closer examination of the tape will reveal that it has a series of holes punched in it spaced according to the desired time intervals. As each hole travels past on electrical contact a circuit is completed which rings the bells. To change the bell schedule, new holes are merely punched or old ones are patched over.

The means by which the clocks in Lincoln Hall are run are a bit different. These are controlled by a "slave" clock, which is in turn run by the master clock. The "slave" clock does not run continuously, but only advances at minute intervals.

The master clock itself is spring driven though the spring is constantly being electrically wound. In the event of a power failure the clock will continue to operate for half an hour. One reason for having installed a spring driven rather than motor driven clock, was that the current was unreliable thirty-five years ago with the result that the speed of the motor would vary. To attest to the accuracy of the spring mechanism Professor McNair rarely finds it more than ten seconds off each month when he checks it.



The Lincoln Hall Clock

In the thirty-five years the clock has been ticking away the only serious trouble impairing it's accuracy was caused by the pendulum, which is made of invar steel having a very low coefficient of expansion. In spite of this its length used to vary enough to throw the timing off. The trouble seemed to disappear though, as the metal aged.

Despite the fact that it performs a remarkable, though routine job, the clock is known to very few people. However, the next time the bell rings just as the prof throws a tough question your way (and catches you with your homework down), remember it was a small hole punched in a piece of paper that saved you.

Cornell Society of Engineers

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George T. Minasian

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

President's Message

On Friday morning, April 27th three students emerged from Sibley with a bundle of lumber and paper and a sledge hammer. After considerable hammering a sign which could easily be read from the Library proclaimed

ENGINEERS' DAY
TONIGHT 7 TO 11 P.M.

I understand that a little later the humorists at White had a sign "Architects' night today 11:30 to 11:32 A.M."

This was my first personal visit to Engineers' Day. I even had a small official part to play as one of the judges for the Best Exhibit Award—a trophy presented by the Cornell Society of Engineers.

In case you don't know it, this Engineers' Day is entirely the result of Student initiative. Their own "Cornell Student Engineering Council" plans the show as a tangible means of fulfilling their objectice to "promote interest in the College of Engineering and the Engineering Profession"—and what a show it is. The enterprise naturally has the whole-hearted support and cooperation of Dean Hollister and the Engineering Faculty.

The judges were certainly impressed and somewhat dismayed when they found over 130 separate exhibits listed by the five schools. However the Council had already considered this problem and each school had selected the two exhibits on which they wished to be judged. Even with the task thus simplified Professor Cuykendall, Principal Frank Bliss of the Ithaca High School and I, starting promptly at 8 P.M. just barely managed to make the rounds and turn in our report by midnight.

The winners were the C.E.s with their exhibit and demonstration of Soil Solidification. This product of Cornell research promises to be a great boon to the farmers and others who find themselves mired during the Spring thaws, and of course the Military use is most obvious. Models of treated and untreated roads with model tractors clearly demonstrated the problem and its solution.

Honorable mention went to the M.E.s for their Industrial Engineering exhibit—the Jet Pump Study—complete with Market Surveys, product analysis production method study and plant layout, all well documented and attractively displayed.

Honorable mention also went to the Chem.E.s for their demonstration of the Rotary Filter Project by the students who were actually doing the original research on this development.

The Engineering Physics boys (and girls) had their hands full with the crowds attracted by a program featuring such intrigueing names ranging from "the suitcase gyroscope with a mind of its own" to the 300,000,000 electron volt synchrotron.

The E.E.s played to worlds fair crowds with exhibits ranging from servomechanisms in actual operation to the Medical "Electronic Plethysmograph" which measures and plots minute changes in the circumference of your finger as the heart pumps blood through the arteries.

My congratulations to all who had a part in staging the superb Exhibit. I hope many more of our Graduates will ocme next year to see it for themselves.

In closing, may I express my appreciation for the privilege of having been President of the Society. It has been a most heart warming experience.

George T. Minasian

Alumni News

Alexander S. Langdorf, M.E '01, has been appointed to write a history of Washington University. He joined the faculty in 1901 and retired in 1948 as dean of the engineering and architecture schools, but still lectures in Electrical Engineering. He lives at 5187 Cabanne Ave., St. Louis 13, Mo.

Cladd H. Chase, M.E. '08, is now associated with Management Counselors, Inc., 37 Wall Street, New York, an advisory group of business executives and engineers, who collectively represent about 2,000 years of experience in business. Chase is retired Distribution Engineer of the Brooklyn Edison Company.

Gilbert Victor Steele, C.E. '10, vice-president, director and chief engineer of Abbott, Merkt and Co., Inc., consulting engineers in New York, died November 2, 1950, at his home at 10 Stuart Place, Manhasset. He had charge of the design of the New York Port Authority Building, two Squibb and Co. plants, and various other industrial buildings.

Allen Arthur Raymond, M.E. '10, superintendent of fuel and locomotive performance for the New York Central System in Buffalo, where he had lived since 1929, died August 30 at his summer home in Westport, Connecticut. He was vice-president of the Air Pollution and Smoke Prevention Association of America.

Paul W. Thompson, M.E. '10, has, during the past forty years, maintained intimate contact with the University through his work with the Board of Trustees and his teaching activities here.

After graduation in 1910 he remained at Cornell to teach at Sibley College and to do engineering work at nearby Auburn. In 1913 he took a job with the Detroit Edison Company and has remained there ever since, with time out to serve as a major in Army Ordnance through the First World War. Now he is vice-president in charge of engineering in that company, a job which places upon him general responsibilities for the design, construction, operation, and maintenance of the company's plants, together with its gas, steam, and electric transmission and distribution systems. In addition, he is now serving a second term as a member of the Engineering Advisory Council to the Trustee committee on buildings and grounds.

Paul W. Thompson

The record of a successful engineer forty years out of college seems fated to become no more than a list of jobs held, hard tasks accomplished, papers read at meetings of learned societies here and abroad, professional recognitions, and honors conferred upon him. From Paul Thompson's factual list, however, there manage to escape concealed evidences of humanity and zest. Besides serving Cornell as a member of the Board of Trustees and in the Cornell Society of Engineers, he keeps bright his military interests through his active membership in the Army Ordnance Association and the American Legion.

The Thompsons live at 1119 Devonshire Road, Grosse Painte Park, Michigan.

Trygve W. Hoff, C.E. '21, has opened a structural engineering, consulting, and designing firm under the name of Trygve Hoff and Associates at 4500 Euclid Ave., Cleveland, Ohio. Among the important jobs in which he has participated were the Niagara Gorge Arch, the George Washington Bridge in Seattle, Washington, the Highland Park Bridge in Pittsburgh, and other major projects in New York, New Orleans, Pittsburgh, Louisville, and Cleveland. During the war he was in charge of the design office at the Ravenna Arsenal and was a group engineer with the Boeing Aircraft Company. He and his wife, Gertrude, and their three children live at 3324 Hyde Park, Cleveland Heights.

Sydney R. Udall, A '28, resigned in August 1949 from Publicker Industries, Inc., to form Pyramid Chemical Co., chemical dealers and distributors at Broad and Arch Streets, Philadelphia, Pennsylvania. His address is 7009 Lincoln Drive, Philadelphia 19.

Eugene A. Walsh, B.S.A.E. '49, is with the testing division of Douglas Aircraft Corp., Santa Monica, Calif., and lives at 7354 Remmet Ave., Canoga Park, Calif.

Prominent Faculty

Dr. Dwight F. Gunder

Anyone who has ever attended one of Dr. Dwight F. Gunder's lectures in mechanics is sure that behind his engineering knowledge lies a vast understanding of mathematics. Therefore, it is no surprise to know that Dr. Gunder, originally from Ames, Iowa, received a B.S. and an M.S. in applied mathematics, both from the University of Iowa, with a minor in physics. Thus his education is buttressed in the sciences most basic to all engineering.

After leaving the University of Iowa, Dr. Gunder taught mathematics at Colorado A and M, and having a rather diversified education in most fields of engineering, he also instructed in civil engineering. In 1933 he added the distinguished title to his name at Wisconsin.

One of Dr. Gunder's main engineering interests is rocket propulsion, and during the war years he was Senior Engineer for the Rocket Research Division of U.S. Army Ordnance. He conducted research on rocket propelled assault weapons, such as gun-fired demolition rockets, continuing this research for M. W. Kellogg Company in 1945.

Dr. D. F. Gunder

Cornell first saw Dr. Gunder in 1940, when he took a semester of resident doctor in order to do some further studying. He returned in 1947 to become head of the Department of Engineering Mechanics, and in 1948 was appointed acting head of the Engineering Materials Department. Right now, in addition to his lectures and administrative tasks, he is investigating liquid shock waves, rockets propelled by solid fuels, heat transfer, and is preparing a new course in non-linear mechanics systems, which will be offered next year.

When Dr. Gunder finds time, he indulges in his favorite hobby of steam tractors. These were quite popular for doing heavy farm work before their replacement by gasoline and diesel tractors, and they resemble locomotives, some of them weighing as much as twenty tons. Dr. Gunder owns one, and although it takes three hours to get up a head of steam, he sometimes runs it. He hopes to add two more to form a collection.

Summers, Dr. Gunder goes west just to relax, but brings along a suitcase-full of books, just in case he feels the urge to do a little work. He has published many papers in the fields of mechanics, rockets, and education, and his professional affiliations include the ASME, ASCE, ASM, ASTM, and SPEE. He has been elected to membership in Tau Beta Pi, Sigma Xi, and Phi Kappa Phi.

But Dr. Gunder considers his foremost job to be not research, but teaching and giving proper attention to the courses given in his departments so that they are continuously modernized, improved, and properly coordinated. He aims to give each graduate a good knowledge of the fundamental principles of engineering, the keystone of Cornell engineering.

Professor Peter E. Kyle

The "man of metal" of the School of Chemical and Metallurgical Engineering is Professor Peter Edward Kyle, Assistant Director of the School, in charge of metallurgy. Although he strikes you as the type who would appear more at home at a meeting of the board of directors of a large corporation, Professor Kyle has the background of the eminent educator as well as that of the successful businessman; and it is this combination which will contine to assure Cornell metallurgical engineering students of the best in top-level leadership.

But, as in every organization, effective top-drawer policy-making often comes about as the result of a thorough knowledge of the bottom drawer, and of its peculiar point of view. Here, as a Cornell graduate himself, Professor Kyle effectively fills the bill. He began his engineering education as a student engineer with Westinghouse from 1927 to 1929, during which time he attended night school at Carnegie Tech. Then, after a short time in the Westinghouse Research Labs, freshman Kyle finally matriculated at the Cornell Mechanical Engineering School with an industrial background which had already put him well ahead of most of his classmates. With McMullen and

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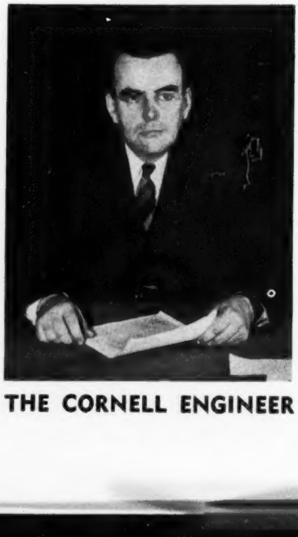
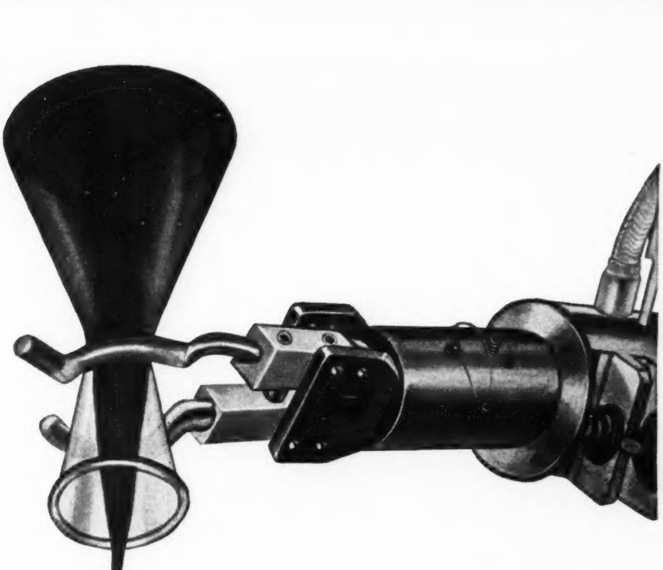
Professor P. E. Kyle





News of the College

Professor McNair Speaks

Professor Arthur J. McNair of the CE school took an active part in the recent conference of the American Society of Photogrammetry held in Washington, D. C. The society, with a membership of over 2400, is composed of men from industry, education and government agencies interested in surveying and mapping by photographic methods. Prof. McNair presented information and led discussions on the extent of photogrammetry in higher education. Particular emphasis was placed on applications to civil engineering.

Photographic methods of map making are rapidly replacing the old survey party in many applications of surveying. The USGS and many state highway departments now do most of their surveying with photographs. Much of the conference was devoted to military applications of photogrammetry and photo-intelligence.

Prof. McNair was appointed chairman of the education committee, and was also appointed to a subcommittee which is setting up plans and specifications for mapping for highway engineering purposes by photogrammetric methods.

Blood Research

Professor of Electrical Engineering William C. Ballard is one of a group working on a method for determining a red blood cell count which far surpasses the old and painstaking visual method.

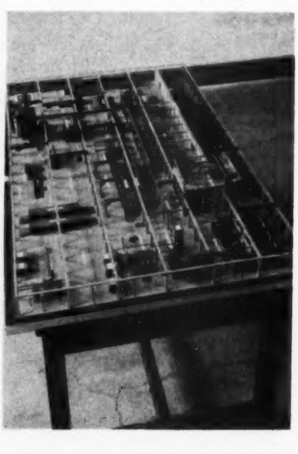
In this new procedure a sample of the blood to be tested is placed in a small vial having electrodes at both ends. The resistance of the blood between the two electrodes is then measured after which the vial is placed in a centrifuge and spun at a speed of about 2,000 R.P.M. This separates the blood into two parts, the clear plasma and the red cells. By measuring the resistance again and comparing it with the first measurement, an excellent approximation of the red cell count may be obtained.

The new method is being developed by the Cornell Medical Center as well as several other hospitals and results so far have found it to be quite accurate. The Army and Navy have also shown interest in it since, in the advent of an atomic attack, where radiation effects would alter the number of red corpuscles in the blood, it can be used to check quickly hundreds of people in a very short time. In fact, the entire operation takes about forty seconds where as the visual method takes more than ten minutes.

Model Foundry

The School of Chemical and Metaallurgical Engineering has been given a model of a proposed new foundry, designed for a foreign customer by Lester B. Knight and Associates of Chicago. The model is now in Olin, and is in use in several courses for instruction purposes. The foundry embodies many improvements in typical foundry practice, especially in materials handling equipment. Mr. Knight is a graduate of the ME school.

Model of an ideal foundry



Curriculum Discussed

Ever since its institution five years ago there has naturally been much speculation over the relative merits of the five-year engineering curriculum as compared to the old four-year program. However, it was impossible to reach any definite conclusions until the first class of five-year men had completed their education and had gone out into industry. With this in mind the Cornell Society of Engineers invited seven graduating seniors to a meeting, held on March 27, at the New York Cornell Club to air their views and tell of their experiences with the new curriculum.

The informal panel discussion, followed by a sharp question and answer period, was headed by Tom Kelly, ME, who acted as moderator. Members of the panel, representing all the engineering schools, were Bob Kaplan, ChemE, Burt Gold, CE, Alex Richardson, EE, Al Blumstein, EP, Al Kopsco, ME (Option A) and Bernie Roth, ME (Option B).

The general consensus of opinion, based upon employer reaction to date and the wide diversity of electives taken by the panel members, was that the new curriculum is definitely superior to the old one. However, it was pointed out that there still remained the need for certain improvements. Criticism was voiced on some of the liberal arts courses, such as Chemistry and English, which freshman and sophomore engineers are required to take. Others, including Economics and Psychology, were considered valuable to the curriculum, especially when presented from an engineering point of view.

Special emphasis was placed on the increased number of elective hours which enable engineers who are interested, to branch out and specialize in widely divergent fields.

(*Continued on page* 38)

Techni-Briefs

Power Transmission

Rain, sleet, and fog are proving to be the most formidable enemies to engineers striving to raise the level of electric power transmission to an all-time high of 500,000 volts. Power leakage caused by such atmospheric conditions may be as high as 80 times the loss during fair weather, and may require additional standby generators to supply the deficiency.

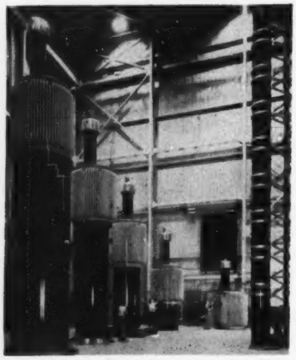
Exhaustive tests are being made on an experimental 500,000-volt transmission line at the Tidd Power Station of the American Gas and Electric Company in Brilliant, Ohio. The highest voltage now being used in actual transmission service is along the 287,500-volt line from Hoover Dam to the Los Angeles area.

The experimental 500,000-volt system consists of three full-size test lines, two of which are approximately one-and-a-half miles long and the third 800 feet long.

A battery of super-sensitive instruments keeps watch on corona losses, radio-influence effects, rainfall, temperature, barometric pressure, and many other factors. To supplement the field tests, a special "rain maker" was designed at the Westinghouse High Voltage Laboratory in Trafford, Pa. to measure the effect of controlled rainfall on a test conductor.

It has been found that heating up of the electrical conductor in actual service prevents condensation of moisture during fog periods and cuts down on the power leakage measured during the tests, in which no temperature increase takes place.

Transformers being used for research on the effects of lightning and other high voltage discharges on power lines.
—General Electric



Chemical Mixer

Installation of a new "fixer mixer" which will nearly double the output of Kodak photographic fixers has been announced by the Eastman Kodak Company. The continuous, automatic mixing machine, which is capable of out-producing the old mixing method by more than 80 per cent, was designed by Kodak engineers and can handle nearly a carload of chemicals a day.

The new operation begins on the sixth floor level where attendants supply from two to five different chemicals required by the specific formula being used. A master control station on this level contains the electronic brain which directs the entire mixing operation and shuts down the whole system if any unit or chemical supply fails.

The hoppers dispense chemicals on the fifth floor where continuous automatic weighing machines control the rate of flow of each chemical. The chemicals then pass into a central hopper and flow to mixers on the floor below.

At the fourth floor level the chemicals are thoroughly blended in two giant mixing machines. Two more chemicals are placed in separate hoppers and added to the mixture by automatic weighing machines on the third floor. The powder is carried by belt to the final mixer, which screens out lumps and then delivers the completed mix to portable storage bins on the second floor.

New automatic chemical mixing system for photographic fixers being filled by portable hopper.
—Eastman Kodak

As each storage bin is filled with fixer, a sample is taken for laboratory analysis. Following the lab quality check, bins are moved over floor ports to serve as hoppers for a battery of filling machines on the first floor.

The huge mixing installation can be stopped by controls at any point in the operation. A vacuum dust removal system carries away chemical dust at all loading hoppers and mixing machines.

Glass Soldered

Glass can now be soldered to metal in a process which makes a bond stronger than the glass itself. The method, which can also be used to solder metal to ceramics and carbon, was originated by scientists.

CORNELL SOCIETIES

Tau Beta Pi

New officers of Tau Beta Pi, the national honorary society in engineering, are Barney Brundage, president; Pete Rose, vice-president; Edward Watson, corresponding secretary; Jack Morgan, recording secretary; and Kirk Birrell, treasurer. The society is planning to hold its initiation and a banquet early in May. A smoker was held at the beginning of April.

Pros-Ops

Pros Ops has recently elected Doug Roberson, Bob McLaughlin, Bob Speer, and Howard Littman to membership. The society has been sponsoring a night "coffee hour" in Olin Hall for the benefit of students working late on projects. Plans are also being made to affiliate Pros Ops with the national chemical engineering fraternity.

Pyramid

Pyramid, the civil engineering honorary fraternity, has held several social functions. A cocktail party was given in the first part of April, and other parties are being planned in the last part of the school year. On Engineer's Day, they presented a project dealing with aerial photography. This spring, Professors Fisher, Slate, Maguire, Gundler, and Conway were elected faculty associates of the fraternity.

American Society of Mechanical Engineers

The American Society of Mechanical Engineers has held several meetings and discussions. Just before spring vacation, Mr. Culver Smith, the University employment counselor, spoke on "Engineering Opportunities in Summer Jobs." This was followed in April by talks by Professor Otto de Lorenzi on methods of burning pulverized coal, and Professor Martinuzzi of the heat power department. A joint meeting with the local section of ASME is being arranged. A speaking contest was held in April and as won by Reino Meritsallio, who talked on "Industrial Engineering Methods as Applied to Dormitory Snack Service." Present officers of the organization are Noboru Kondo, chairman; Phillip Gottling, vice-chairman; and Robert Siegfried, secretary.

American Institute of Electrical Engineers

The student branch of the American Institute of Electrical Engineers will also hold election of next year's officers late this term. Present officers are Barney Brundage, president; Ted Holmes, vice-president; Herman Hanemann, secretary; and Lloyd Hobson, treasurer. Meetings of interest to EE's have been held by AIEE at least once a month throughout the spring.

American Society of Civil Engineers

The American Society of Civil Engineers also has been active in the last months. Late in March they held a joint meeting with the Ithaca College section at which Mr. Linton Hart spoke on concrete pilings. During April ASCE took a field trip to Mt. Norris Dam, presented a movie on concrete construction, and sent its officers to the student convention at Clarkson Institute of Tech-

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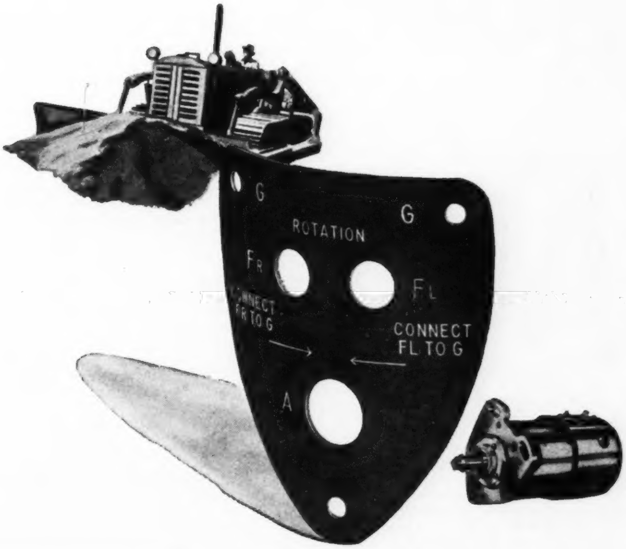


How to move mountains—non-stop

When it comes to moving mountains—or spreading the landscape around—you can't beat bulldozers.

You can, however, beat a bulldozer if you put into it a part that can't stand the gaff.

An example is the generator. Vibration, abrasive dust, weather, shifting stresses and stray oils or greases are constantly taking their hardest licks at it. It leads a tough life.

That's why American Bosch Corporation, makers of dust-proof, heavy-duty generators for industrial tractors and bulldozers, selected Synthane laminated plastics for the insulation plate shown above.

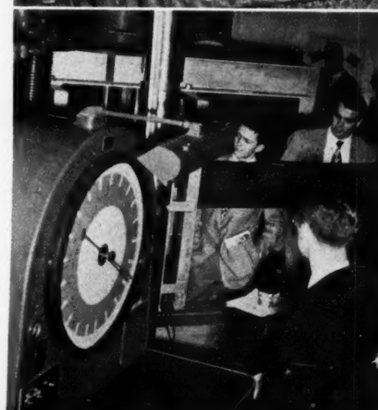
Synthane is a material for industry. It possesses an unusual *combination* of physical, mechanical, chemical and electrical properties.

Synthane is light, strong, dense, abrasion resistant. It is easily machined or produced in formed shapes. Dielectrically strong, it is a natural for electrical applications. Synthane is corrosion and fungus resistant, chemically inert, stable over a considerable temperature range.

If this capsule description of Synthane piques your imagination, send for the complete Synthane catalog. Synthane Corporation, 10 River Road, Oaks, Pennsylvania.

PLASTICS WHERE PLASTICS BELONG **SYNTHANE** S

1951 ENGINEERS' DAY



A new and streamlined Engineers' Day was presented to the public on Friday evening, April 27th. In an effort to avoid conflicting with Cornell Day athletic activities on Saturday afternoon, but still give the visiting sub-frosh an opportunity to see the exhibits, Engineers' Day was held Friday evening from 7 to 11 P.M. To enable visitors to see all the exhibits in the time available, Engineers' Day 1951 was planned to contain fewer, though more elaborate, exhibits than were prepared in previous years.

E-Day 1951 was sponsored and planned by the Cornell Student Engineering Council, and was actually produced by over 300 engineering students. Tom Kelly, ME '51, was general E-Day chairman, and the school chairmen were: Bill Brasie, ChemE, Ed Watson, CE, Al Bishop and Joe Hesse, EE, Bill Jahsman, EP, and Dick Teed, ME. Bob Kahle, ME '55, was publicity chairman.

Over 120 exhibits were presented for Engineers' Day. Two exhibits in each school were judged for the Best Exhibit Award, a trophy presented last year by the Cornell Society of Engineers. Winner of the award was the C.E. School's soil mechanics exhibit, which demonstrated a method of soil solidification, developed by Prof. Hough at Cornell. By means of the new method, ordinary soil can quickly be treated so that it will support heavy vehicles even in rainy weather.

First honorable mention went to the M.E. School for the jet pump study presented by the administrative engineering department. This display showed the results of a senior project in which 17 Option B men participated. Second honorable mention was awarded to the ChemE's rotary filter project.

Other C.E. exhibits included a display of heavy construction and maintainence equipment, loaned by the City of Ithaca, and a laboratory demonstration of water purification.

The M.E. sequel to last year's popular ram jet exhibit was an operating set-up of an aircraft turbo-jet combustion chamber. In addition to this spectacular display, all the equipment in the mech labs and in the production machine tool labs was operated and explained.

Many interesting exhibits were presented by the E.E. School, scientifically designed so that anyone could understand them. The Ham Club brodcast messages anywhere in the country through the amateur's radio network. Rand Hall contained several displays, including an instrument which showed the deflection of a 4-inch steel shaft when touched with the hand. The tube lab in Franklin made and gave away light bulbs and vacuum tubes as E-Day souvenirs.

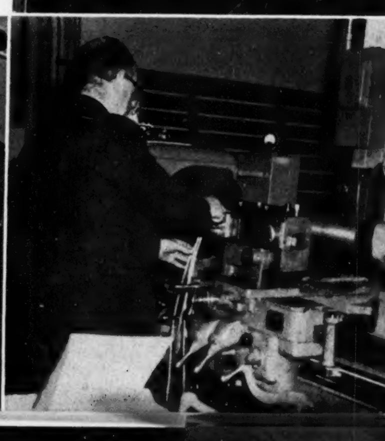
Chem.E. demonstrated the equipment in the three-story unit operations laboratory, showing how this equipment was used by seniors in solving their research problems. This exhibit was especially popular with the sub-frosh, over half of whom were prospective ChemE's. The MetE's demonstrated aluminum casting and casting production operations in the foundry.

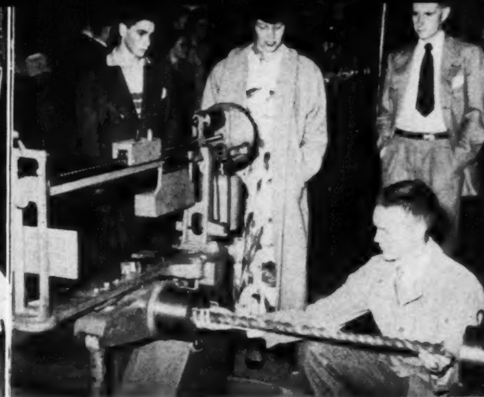
The annual Engineering College softball championship was played on Saturday, April 21st, as a prelude to E-Day. Despite a cold wind blowing from the lake, a fairly good crowd of engineers appeared at Stewart Park at 2 P.M. In the finals, the M.E. School trounced the Surveyors 15-0 to win the College Softball Trophy.

The climax to the E-Day weekend was the Engineers' Day Banquet, presented by the CSEC on Sunday evening, April 29th. Those who attended were treated to an enjoyable talk on "some aspects of engineering not found in books," by Prof. B. K. Hough of the C.E. School. Presentation was also made of the E-Day awards, and of several other awards by various engineering honoraries.

The ENGINEER congratulates all of those who contributed to the success of Engineers' Day 1951. It is a truly enjoyable event in which *all* engineers can participate, and is becoming more popular and successful every year.

***Below*: In Rockefeller Hall the Engineering Physics department displayed this powerful electron microscope which is currently aiding new research projects at Cornell.**





Upper left: These feminine E-Day tourists find themselves very much at home before one of the foundry's ovens where dry sand moulding cores are in the process of being baked.

Above: That segmented pipe in the background is the bubble plate tower located in Olin Hall's huge industrial process laboratory, where it is being used for experiments in fractional distillation. Looks like the guides have some explaining to do.

Upper right: Not a pretzel-twister, but a torsion testing machine is this piece of equipment being adjusted in the West Mech Lab.

Left: Kid gloves are not the proper uniform for handling the hot metal these lads are pouring. The scene is the foundry, where visitors observed the basic steps used in making castings.

Right: Tension mounts in the East Mech Lab where this testing machine is on the verge of pulling apart a bar of steel.

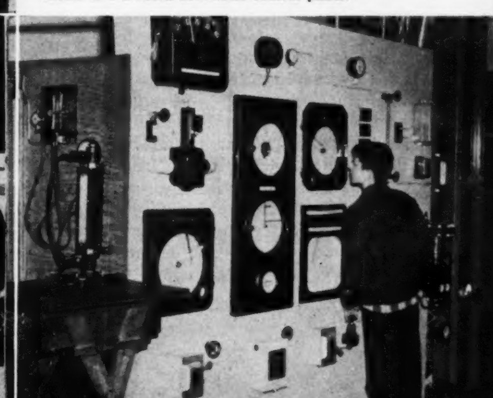
Far left: The skeptical and amused watch a vertically loaded Z-beam deflect laterally in Lincoln Hall Materials Laboratory.

Left: Puzzled people ponder a problem in soil mechanics. This and other displays brought first place in the exhibit contest to the Civil Engineering Soils Testing Laboratory.

Third from lower left: Professor E. K. Henriksen, Head of the Materials Processing Department is shown operating the new lathe with which he is performing experiments on tool pressures and cutting speeds.

Second from lower left: Two young engineers gleefully contemplate the possibilities of Civil Engineering's latest refinement of a standard plumbing fixture.

Below: A future industrialist boldly conquers the intricacies of a modern automatic control panel.



Turboprop Engines

(*Continued from page* 8)

mph). Also, the length of the takeoff can be reduced considerably because of the variable pitch propeller which permits large increases of thrust. A turboprop engine has the same essential organs as a turbojet (air intake, compressor, combustion chamber, turbine and tail pipe); in addition the turbine shaft, beside driving the compressor, is connected with a reduction gear which transmits a power output at suitable speed to a propeller of the usual variable pitch type. Sometimes two counter-rotating propellers are used to reduce the diameter and eliminate torque reaction. Notwithstanding the great similarity in the structure of turbojet and turboprop, they operate in an essentially different manner. In the turbojet the hot high-pressure gases have only a partial expansion in the turbine to a pressure substantially higher than that of the atmosphere, so that the turbine gives only just enough power to drive the engine; a further expansion takes place in the tail pipe to accelerate the exhaust gases. In the turboprop the expansion of the hot gases takes place almost exclusively in the turbine, so that the power delivered by the turbine is substantially greater than that absorbed by the compressor, while the exhaust gases get little or no acceleration in the tail pipe. Consequently a turboprop turbine has generally more stages (turbine wheels) than a corresponding turbojet. The difference between the power delivered by the turbine and that absorbed by the compressor is the useful power and is transmitted to the propeller; there is also a small jet effect due to the velocity of the exhaust gases, but this generally accounts for only a small fraction of the total power of the turboprop.

Consequently a turboprop is an engine in the accepted sense of the word; its power, weight and specific fuel consumption are almost independent of the speed of the aircraft. A modern turboprop engine weighs about .5 lb/HP and the fuel consumption is about .7 lb/HP/h. These figures are considerably better than those of a good turbojet if the aircraft speed is lower than 500 mph. Comparing a turboprop with the best piston engines, the weight of the turboprop is considerably lower and the frontal area is smaller; but the fuel consumption is not as good. Consequently, the immediate applications of the turboprop will be on medium range medium speed aircraft, in which the weight of the engine plus fuel is lower than that of a piston engine.

The first turboprop engines were designed and built just after the war in Britain and in the United States; there were great hopes that they would be as successful on slower aircraft as turbojets had proved to be on fast planes. In 1946 many experts were confident that in a year or two commercial aircraft would normally use turboprops to cross the Atlantic. Piston engines are limited in power to a maximum of about 4000 HP. Consequently most large modern planes, bombers and

(*Continued on page* 26)

The Most Important Job in the World

O. V. TALLY

by O. V. TALLY, *Manager, Midwest Region, General Machinery Division,* ALLIS-CHALMERS MANUFACTURING COMPANY *(Graduate Training Course, 1927)*

YOUR FIRST JOB is the most important job in the world. Picking that first job carefully can mean the difference between a running start in a really satisfying life work and merely working for a living. You must have been giving this problem a lot of thought as you look toward the end of your scholastic career. I had exactly the same problem while I was working for my E. E. at North Carolina State in 1925.

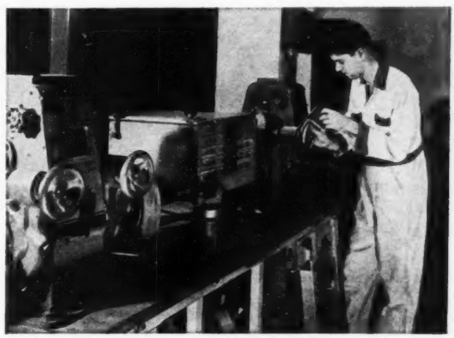
I happen to think that the man who applies his company's product in the field is the most important man in the American business system. Not only does he help create the demand that keeps our factories working, he is also the force behind many of the great improvements in products and processes which have been made. He must know and understand the customer's problems and the factory's facilities, then bring the two together to produce better goods at lower cost.

I knew I wanted this kind of work. Most of all, I wanted to be free to try several fields of work; to find out where my talents lay; to see where my individual effort would bring the greatest satisfaction.

Allis-Chalmers Serves All Industry

I chose the Allis-Chalmers Graduate Training Course because Allis-Chalmers has a hand in solving the problems of every basic industry . . . food, steel, mining, aluminum, electric utilities, public works, chemicals, and many others. Here I saw my chance to find out which I wanted to work in.

Taking the course in many different departments, I learned as much as I could about as many products and industries as I could. Then I began application engineering in the New York District Office. Since then, I have been in Washington, Philadelphia, St. Louis and Chicago. As it turned out, I didn't specialize in any industry, but worked on applications for all kinds of goods to many industries.



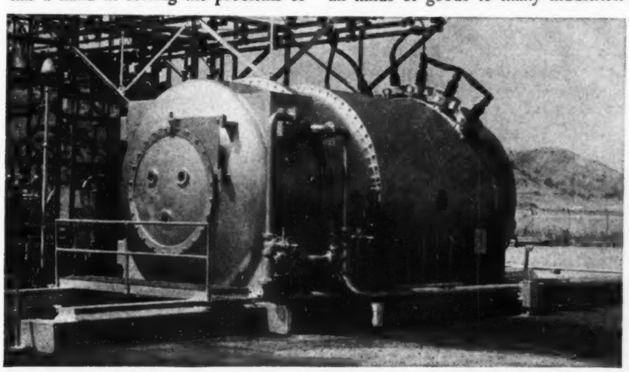
In Basic Industries laboratory scaled-down equipment is used to investigate processes and make pilot runs. Lab includes complete food, ore, wood, rock products pilot plants.

And I found the work that has made me happy.

Find Your Spot

Of course, not everyone wants to be a field application engineer. The Allis-Chalmers Graduate Training Course offers you an opportunity to find out which branch of industry you will be happiest in and which job in that industry you can do best. You choose your own courses and may alter them whenever you like. You choose among electric power generation, distribution and utilization equipment; motors, pumps, blowers; basic industry equipment for processing cement and rock products, ores, wood, chemicals, food; and many other types of equipment. You can get actual practice in design, manufacturing, sales, research, administration, service and erection before choosing which one to follow. And many Allis-Chalmers customers have openings for training course graduates.

As I've said, I believe the most important job in the world to you is your job after graduation. Choose the job that gives you the greatest opportunity for advancement through your own effort. If you want to talk to someone about the opportunities at Allis-Chalmers, visit your nearest Allis-Chalmers Sales Office. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for details.



Large Allis-Chalmers synchronous condenser corrects power factor on giant Southern California Edison Company distribution system.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

Turboprop Engines

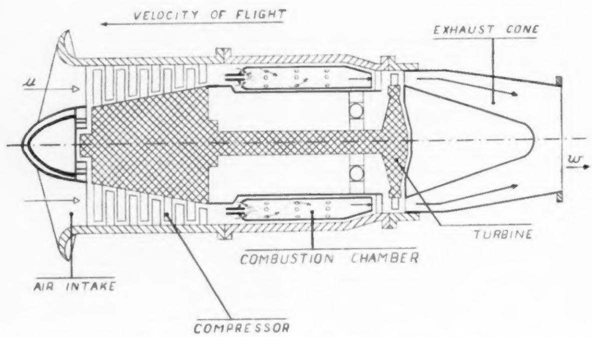
(*Continued from page* 24)

airliners, are underpowered. Turbines are more suitable for large powers than piston engines so that the turboprop seemed the logical solution to obtain big engines up to 10,000 HP. The early American turboprop designs were high-powered engines, while British turboprops were much smaller (1000-3500 HP). Very soon, however, it became obvious that the development of satisfactory and reliable turboprops was a much longer and more difficult problem than the production of good turbojets.

Although turboprops and turbo-

These vibration problems proved so serious that the development of the turboprop was slowed down for several years and there were even doubts whether this type of engine would prove economically justified. Of course, the more powerful engines gave the greatest trouble.

Last year, however, interest in the turboprop suddenly revived. The smaller turboprops proved at last their reliability; to produce larger powers, two relatively small engines (1000 to 3500 HP each) were paired and connected to a common reduction gear and a common propeller shaft. There is, of course, no intrinsic advantage in pairing two small turbines, reliabil-



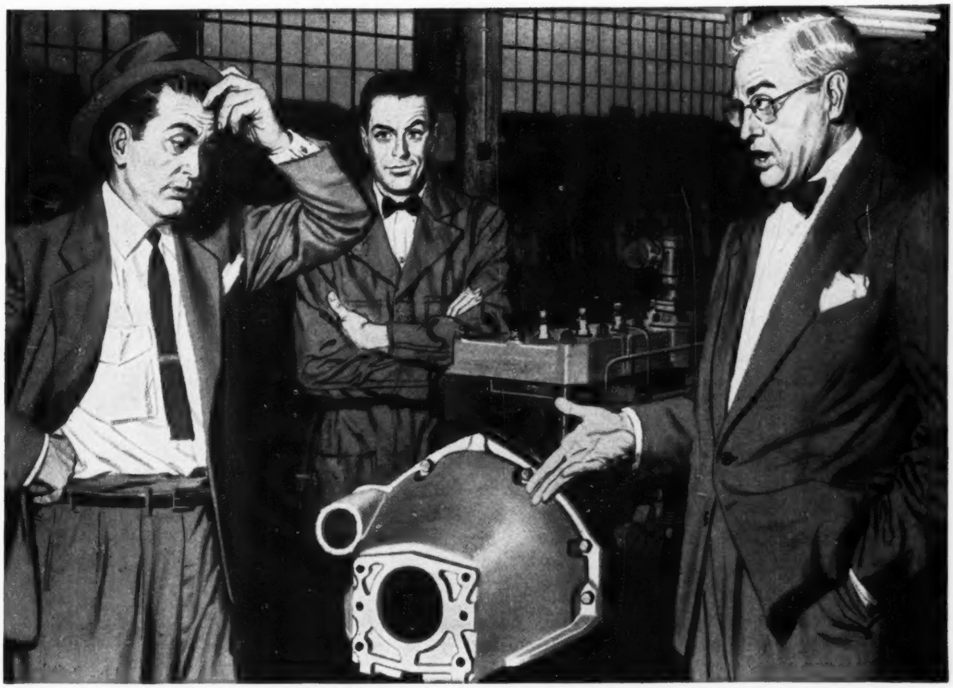
The turbojet engine derives all its power from the force exerted by the escaping gases.

jets are so similar in appearance, the conditions under which they operate are in reality quite different. In the turbojet, turbine and compressor have no direct connection with any outside organ; they automatically find the most suitable speed for each power level and are insulated from outside shocks and vibrations. In a turboprop, on the other hand, the output shaft is connected to the propeller through the reduction gear. Both gears and propeller are rich sources of induced vibrations, which are fed back to turbine and compressor. The weight of the turboprop must be kept very low and consequently the machine has very little inherent rigidity and is therefore very sensitive to vibration conditions; the bigger the machine, the longer are the turbine and propeller blades and the worse they vibrate.

ity is decreased, because any damage to one of the turbines requires immediate stopping of both, while the weight of two paired turbines is greater than that of a single turbine of equivalent power. The real advantage of paired turbines is that, under present conditions, two small turbines coupled together will work reliably while a large sized single turbine gives trouble. There is little doubt however, that in a few years larger models will prove equally satisfactory.

In this country, the first model that resulted from this revived interest was the Allison turboprop produced as a single turbine giving 2750 HP or as a paired turbine giving 5500 HP. The development of this type of engine was sponsored and encouraged by the Navy; tur-

(*Continued on page* 28)



Turboprop Engines

(*Continued from page 26*)

boprops are particularly suitable for taking off from aircraft carriers. A recent American development in propellers for high speed aircraft will favor the use of turboprops. Up to now, propeller efficiencies fell strongly at high speeds when the propeller blades go at speeds faster than sound, and energy is dissipated generating sound waves. The recent American improvements have produced supersonic propeller blades which waste much less energy, so that turboprops can probably be used without excessive loss on planes flying up to 550 mph.

At the present moment, nearly all American aircraft engine manufacturers have turboprop engines under development; these are either based on original designs or are built under British license. None of these turboprops has yet been flown as a production model on regular service. The most advanced is the Allison, which will be fitted to an experimental airliner and also to several naval aircraft. Many of the new designs for large planes, bombers or airliners are being prepared with alternative engine arrangements, turboprops or turbojets. If by the time the prototypes are built the new turboprops have proved their worth, they will be used in preference to turbojets. In Britain, a small turboprop has been flown on an airliner in commercial service. The response of the public was enthusiastic because the plane is quite silent and does not vibrate. The present prospects of the turboprop are therefore good; if it is not put in commercial service too soon (a bad accident would retard its adoption for years) there is every chance that in the near future it will find many applications in medium speed medium range aircraft.

But for the more distant future the possibilities of the turboprop are very much brighter. Research on high-temperature metals and on turbine blade cooling gives promise that the maximum gas temperatures before the turbine will be raised from about 1650°F, as they are now, to 2200 or even perhaps 3000°F. In that case both power output and efficiency will be greatly increased and a reduction in fuel consumption of .4 lb/HP/hr or less will become possible. Then the turboprop will be not only lighter than the piston engine but also its fuel consumption of .4 lb/HP/hr or more it will be the ideal engine for long range aircraft. The same increase in turbine temperature will not improve the efficiency of the turbojet, unless the aircraft speed is increased at the same time; but turbojets become impractical at speeds of above 900 mph and, whatever will be the progress of supersonic aviation, it seems unlikely that commercial aircraft will fly above the speed of sound. Consequently the future high efficiency turboprop engine will probably be fitted to most commercial aircraft and to long range military aircraft, unless by that time military aviation is either abolished or composed mainly of guided missiles.

Cornell Societies

(*Continued from page* 20)

nology. Edward Watson is president.

Delta Club

The Delta Club, the student-faculty organization of the EE college, has for its present officers, Hugh Thuerk, president; Ed Crocco, secretary; and Don Hayes, treasurer. In mid-April the club held a smoker to give both student and faculty members a chance to meet prospective new members, and planned to hold an initiation soon afterward. During May they are holding a picnic, and the year's agenda will be concluded with a banquet just before final examinations.

American Institute of Chemical Engineers

Early last month Mr. John Callahan, Editor of *Chemical Engineering Magazine,* spoke before the Cornell branch of the American Institute of Chemical Engineers on the role of ChemE's in the industrial world. The group plans to have another speaker in May. They have also been busy preparing several exhibits for Engineer's Day. AIChE is sending two student groups this spring to the Regional Conference at Rensselaer Institute to present papers prepared in conjunction with their senior research projects.

Al-Djebar

Al-Djebar has also been active socially in the past few months. They have recently held two dinners, and another is being planned. There have also been several evening social gatherings, something of a tradition with Al-Djebar. The annual picnic, featuring a softball game between Chem Majors and ChemE's will be held later in the spring. Officers this term are Phillip Shapiro, A. B. Cohen, William Brasie, and Robert Caplan.

Cornell Student Engineering Council

The main activity of the Cornell Student Engineering Council this spring has been the planning and running of Engineers' Day. Tom Kelly has been in charge of organizing and setting up exhibits from the various engineering organizations. The council has also started a coordinating committee to serve as a clearing house for engineering societies so as to avoid conflicting meetings, and to perform other such services. Late in the spring term, one member from each of the engineering schools will be elected to the Council. The present officers are Loren Kahle, president; Paul Widener, vice-president; and Ted Holmes, secretary.

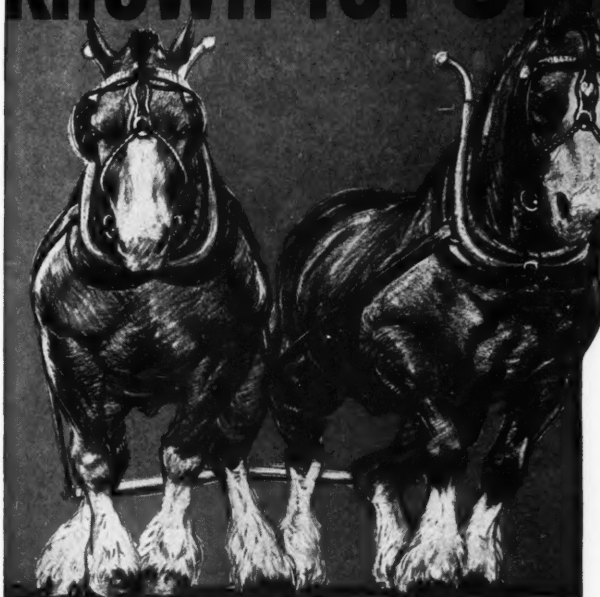
Cornell Society of Engineering Physics

The Engineering Physics Society, whose officers this year have been Nilda Altman, president, Ted Wong, treasurer, and Jan Button, secretary, had for its first meeting in the fall a talk on the electron microscope by Prof. Siegel.

Another very interesting meeting consisted of descriptions of summer experiences by fifth-year students, all but one of whom held jobs last summer. John Gay told of his work on rocket flight computers at Franklin Institute in Philadelphia, and Ted Schultz described his job at Philco. E.P.'s at Oak Ridge were Bill Jahsman, Frank Loeffler, Jim Schwartz, and Leon Bush. Others who spoke of their jobs were Eldred Paufve, Eastman Kodak in Rochester; Charles Peterson, Bell Telephone Lab in New York City; and Nilda Altman, Nuclear Physics Lab here at Cornell for her second summer.

Other E.P. Society meetings to be held this term will consist of a series of talks by students on their senior projects. Officers will be elected this spring for the coming year, and the final meeting for this year will be a picnic to be held sometime in May at Enfield or Taughannock.

known for STRENGTH



In city streets lay pipe known for STRENGTH

CRUSHING STRENGTH

The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH

When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

SHOCK STRENGTH

The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times on the same spot from progressively increased heights of 6 inches.

BURSTING STRENGTH

In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

Known strength factors! Proved resistance to corrosion! These are your only safe and sure guides to long life and low maintenance expense of water, gas and sewer mains laid under costly modern pavements. The four strength factors that pipe must have to survive traffic shocks, heavy external loads, beam stresses and severe working pressures are listed in the box opposite. *No pipe that is deficient in any of these strength factors should ever be laid in paved streets of cities, towns and villages.* Cast iron water and gas mains, laid over a century ago, are serving in the streets of 30 or more cities in North America. These attested service records prove that cast iron pipe not only assures you of effective resistance to corrosion but all the strength factors of long life and economy, as well.

CAST IRON PIPE RESEARCH ASSOCIATION, THOS. F. WOLFE, MANAGING DIRECTOR, 122 SO. MICHIGAN AVE., CHICAGO 3.

CAST IRON PIPE SERVES FOR CENTURIES

Nodular Cast Iron

(Continued from page 10)

much significance. With an average strength of about 90,000 psi, it shows an elongation of 1 to 3 per cent, which is still appreciably better than that obtainable with grey cast iron.

Compares to Steel

For comparison of these mechanical properties, it might be interesting to look at those of some of the other ferrous metals. Although there are variations within each class of materials we consider, some sort of typical values will be aimed at. A good alloy grey iron has a strength of 50,000 psi, while malleable may be expected to show a value of about 56,000 psi. The steels, on the other hand, are appreciably higher. As for elongation, grey iron has virtually none and malleable demonstrates about 20 per cent.

An interesting property to consider is the modulus of elasticity, Young's Modulus, which is measured by the slope of the straight-line portion of the stress-strain curve. With respect to this property, the nodular iron more closely resembles steel than it does grey iron. Steel, whose curve flattens out at the yield point, has a modulus of 30,000,000 psi. For grey cast iron, there is no straight portion to the curve, i.e., it exhibits no elastic behavior, and a secant modulus is approximated. Nodular iron, on the other hand, shows an elastic portion to the curve with a slope of about 25,000,000, a value relatively close to that of steel.

Casts Easily

The big advantage of nodular iron, as regards steel, is its excellent castability—as good as that of grey cast iron. There are many intricate parts which cannot be made by any of the steel forming processes. Previously, these had to be cast in grey iron, accompanied by the brittleness and lowered strength associated with this material, or in the more expensive cast steel. Here we see one of the major future applications of nodular cast iron—in providing better properties to intricately shaped pieces.

Much use is expected also to be made in pipes and pressure vessels. Grey iron, when used in such applications, developed leaks as a result of the continuous path through the material resulting from the proximity of the graphite flakes. This problem does not present itself with the nodular structure.

In general, applications will be most plentiful where a relatively cheap and easily producable product is desired, but whose property requirements as regards shock resistance, ductility, and strength are more stringent than those grey cast iron can satisfy. Much of this, at present, is in the line of agricultural and automotive fields.

Much work still has to be done in finding the place for nodular cast iron in our industrial economy and to fit it to best fill that place, but it is a safe bet that the place will soon be found, and that, in only a few years, nodular cast iron will be a major engineering material, ranking behind steel and grey iron.

THE DU PONT DIGEST

Research Takes the Long View

Fundamental studies are one of the most important phases of Du Pont research

Fundamental research is designed to discover new scientific facts without regard to specific commercial use. Yet from it have come many products of commercial significance.

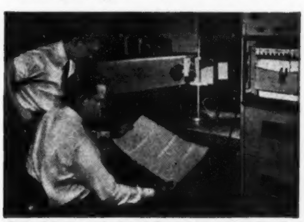
At Du Pont, for instance, fundamental research has pointed the way

Where long-range and fundamental research is emphasized: the newly enlarged Du Pont Experimental Station near Wilmington. Photo Aero Service Corp.

to products like nylon, the first wholly synthetic organic textile fiber, and neoprene chemical rubber, to name only two.

Expanding for Tomorrow

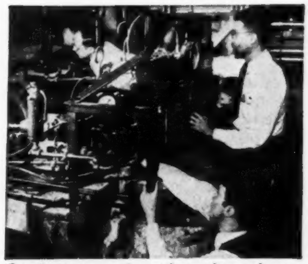
With the expectation that still more "products of tomorrow" will come from the test tubes, flasks and stills of the research laboratory, the Du Pont Company recently expanded its Experimental Station near Wilmington. In this thirty million dollar addition, major emphasis is being given to long-range and fundamental research.



Examining an infra-red spectrogram of polyvinyl alcohol in connection with the fundamental physical characterization of the polymer: J. R. Downing, Ph.D. Physical Chemistry, Illinois '40, and D. G. Pye, Ph.D. Physical Chemistry, Stanford '43.

The enlarged Experimental Station with its 20 new buildings represents one of the largest and best-equipped research establishments in the world. Even so, less than half of the Company's total research personnel is situated here. Du Pont laboratories in more than 25 other locations also carry on both fundamental and applied research.

There are now about 800 technical people engaged exclusively in research work at the Experimental Station. Assisting them are 1,500 others, in technical and non-technical capacities. The research people represent a wide range of training. Among them are organic, inorganic, physical, colloid, analytical chemists and biochemists; physicists and biophysicists; chemical, mechanical, metallurgical, electrical and electronics engineers; plant pathologists, plant



Carrying out experimental autoclave polymerizations of condensation polymers: J. H. Blomquist, Ph.D. Chemistry, Ohio State '41; O. A. Bredeson, Ph.D. Chemistry, M.I.T. '41; J. E. Waltz, Ph.D. Chemistry, Indiana '41.

physiologists, agronomists, entomologists, horticulturists and others trained in biological science. In addition, there are specialists who are not classified in any of these groups.

Free for Research

At the Du Pont Experimental Station every effort is made to permit the research man to concentrate on research. He is provided with the most modern laboratory tools and for the construction of special equipment he can call on a wide variety of services. These include machine shops, carpentry, electrical, welding, instrument-making, and glass-blowing shops. When the research worker needs any service or equipment within the scope of these shops, it is provided for him.

At this industrial research laboratory, Du Pont scientists are devoting themselves to extending the frontiers of science and creating "Better Things for Better Living . . . through Chemistry."

DID YOU KNOW THAT . . .

Nylon came out of a fundamental research program begun in 1927. However, it took 13 years and $27 million in research and operative investment to get into satisfactory commercial production.

DU PONT

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Entertaining, Informative — Listen to "Cavalcade of America," Tuesday Nights, NBC Coast to Coast

Faculty—Prof. Kyle

(*Continued from page* 14)

Westinghouse War Memorial Scholarships to help keep the treasurer's wolves away from the door, and a keen interest in his work, it was not surprising that young Kyle was still on the hill when his class' last bustee had taken the Black Diamond back home. As an undergraduate, recognition of his abilities was not long in coming. Election to Atmos and Tau Beta Pi was followed by election to the editorship of the *Sibley Journal of Engineering*, predecessor to the present-day CORNELL ENGINEER. June of 1933 brought graduation, and an embarkation on a long and successful career as industrialist, scientist, and educator.

Following graduation came a one-year stint at Lehigh University, where he held the James Ward Packard Fellowship in Mechanical Engineering, while engaged in research on wear of bearing metals. Then, from 1934 to 1946, Professor Kyle held forth at the Massachusetts Institute of Technology, where he progressed from Assistant Instructor to Associate Professor of Mechanical Engineering. Here he took charge of a group of courses dealing with engineering materials and processing of metals, and also taught courses in machine design at the Lowell Institute School. It was while at M. I. T. that he was elected to Sigma Xi, national scientific honorary society; and here also that he received his degree of S.M. in M.E. in 1939.

During the war, Professor Kyle took on an extensive program of both educational and industrial work. While teaching courses in materials to students of the various armed forces schools and programs at M. I. T., he also acted as a Supervisor of Research at the Institute, representing the Office of Civilian Research and Development. One of the principal projects was the investigation of methods of improvement of low alloy armor plate by flame treatment. In 1943, he took a leave of absence to take a position as Research Supervisor to the War Metallurgy Committee of the N. A. S. In addition, Professor Kyle was engaged as research supervisor on a number of other projects for the armed forces. These included an investigation into the effects of sudden application of loads to metals, as related to the resistance of armor plate to penetration by projectiles, as well as a statistical survey of acceptance test data on ordnance forgings. At the same time he was engaged in projects dealing with the evaluation of corrosion-resisting alloys for quartermaster items, the development of improved techniques in magnesium alloy production for the aircraft industry, and a project involving the production of press and hammer forgings, also for the aircraft industry.

Returns To Cornell

It was in July, 1946 that Professor Kyle returned to Cornell, as Professor of Applied Metallurgy. Then, in 1947, came a program of expansion of the metallurgical facilities of the School, with the consequent change of name to the School of Chemical and Metallurgical Engineering. This program was furthered no little by the creation of the Francis Norwood Bard Professorship of Metallurgical Engineering, and the subsequent appointment of Professor Kyle to fill this position, including duties as Assistant Director of the School. These duties have included two principal projects: the installation and improvement of the new ten-term curriculum in metallurgical engineering, and the development of research facilities for testing steel foundry sands at elevated temperatures.

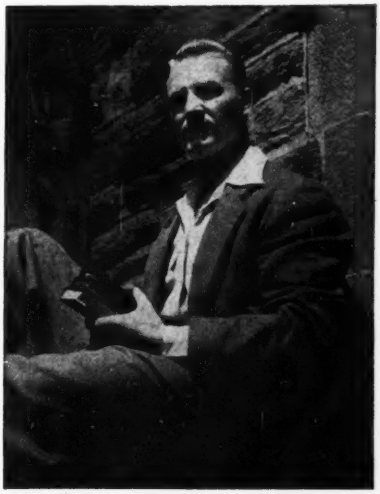
While Professor Kyle tries as far as possible to stay abreast of his field by attending the periodic meetings and conventions of the various professional societies of which he is a member, he does not do so at the expense of his activity in the classroom. He teaches a number of classes in metallurgy, and is a firm believer in as close as possible a relationship between the students and the upper strata of the faculty. The Metallurgical Engineering schedules are usually arranged so that he teaches each man for at least two terms, once in the third or fourth term and again just before graduation. By doing so, he

(*Continued on page* 36)

YOU REMEMBER LOU . . .

He'd Give His Eye Teeth For This Opportunity

Lou came out of W. W. II with the bug for electronics. He'd been an electronics maintenance specialist in the Navy . . . attended service schools in radar, sonar and gunfire control to earn his petty officer's rating. He came to school under the GI Bill . . . majored in electronics . . . now has his degree in electrical engineering. Lou is doing all right now but wishes he could be closer to his chosen career — *electronics.*



Maybe you know Lou—or somebody like him. Perhaps you yourself have a similar background and can qualify for this unusual opportunity to secure broad foundational experience in the rapidly growing field of electronics engineering.

RAYTHEON GOVERNMENT FIELD ENGINEERING

GOVERNMENT FIELD ENGINEERING is our name for the Raytheon organization which supplies world-wide technical service to the Government relative to the intricate electronic equipment which we manufacture. This highly qualified group has won an acknowledged eminence among similar organizations. During World War II, Raytheon produced more search radar for the Navy than all other manufacturers combined. Its Submarine Signal Division has been the leader in sonar and underwater sound since 1901.

Since V-J Day, Raytheon has continued in all phases of electronics development and production for the Army, Navy and Air Force, and is now being called upon to gear its facilities to the growing needs of the Armed Forces. We now have a limited number of openings for candidates who have the special service and educational background required and who can meet the rigorous qualifications which we must impose in order to maintain our high operating standards.

JUNIOR FIELD ENGINEER

Successful applicants for the position of Junior Field Engineer in the Raytheon Government Field Engineering Organization will have the same general biography as our friend, "Lou". Military experience with electronic equipment in the Army, Navy or Air Force is desirable. A degree from a school of Physics or Electrical Engineering in a recognized college or university is essential. Experience after graduation is of little consequence.

The position of *Junior Field Engineer* presents a rare and unusual opportunity to become acquainted with the most modern techniques in the science of electronics. For the graduate engineer, it is a once-in-a-lifetime chance to familiarize himself with the many phases of electronics prior to specialization.

Junior Field Engineers are called upon to (1) supervise equipment installation, (2) supervise or personally attend to its repair and maintenance, (3) train military or other qualified personnel to operate, repair or maintain it, and (4) contribute toward the solution of engineering problems which may arise in the field. The Junior Field Engineer may be called upon to undertake important missions of a classified nature in the interests of the Government. He will at all times, by the nature of his position, be a representative of the Raytheon Manufacturing Company responsible for sustaining and improving our relationship with and service to the Government.

SALARY AND BENEFITS are liberal, commensurate with the technical knowledge and skill and the responsibility involved. They include travel and subsistence payments, free accident insurance, low cost life insurance, retirement and hospitalization plans. All in all, this adds up to a job for which only a relatively small group of engineers can qualify, but in which successful applicants can profit more professionally and financially, can advance more rapidly, and can acquire a wider range of valuable and interesting experience than in any other branch of the industry.

WHO CAN QUALIFY?

Practicing engineers, recent graduates and those about to graduate are eligible to apply; preferably those between the ages of 22 and 30. If you know of a qualified applicant, you will be doing him a tremendous favor by calling this opportunity to his attention. All applications will be carefully considered and held strickly confidential. Send a brief resume to

Government Field Engineering

RAYTHEON MANUFACTURING COMPANY

138 RIVER STREET · WALTHAM 54, MASSACHUSETTS

RAYTHEON

Excellence in Electronics

Technibriefs

(Continued from page 18)

of the G-E Research Laboratory, and is currently being tested for industrial applications by the company's General Engineering Laboratory.

The glass and metal areas to be soldered are painted with a thin layer of titanium hydride, and solder is placed upon both painted areas. The parts are placed together and then heated under a vacuum. When the temperature reaches about 900° Fahrenheit, the titanium hydride decomposes. This causes the solder, which has already become molten, to adhere to the titanium-painted areas of both the glass and metal. A strong, tight bond is formed upon cooling, according to the engineers.

By using soft metal solders, it is possible to subject this glass-to-metal seal to rapid temperature changes without danger of cracking, despite the wide difference in temperature expansions between glass and metal. This is possible because the differences in movement are absorbed by the solder.

Miniature Tube

A tiny electronic tube, similar in principle to those used in radar and in quick-cooking electronic ovens, has been developed by General Electric Company engineers for use in ultra-high-frequency television receivers.

Ultra-high-frequency channels, when released for use by the Federal Communications Commission, will require a special tube to convert the UHF signal to a usable frequency.

The tube designed, by G-E engineers to do this, "beats" down the UHF signal by sending out its own signal which, when mixed with the UHF signal, produces a resulting lower frequency.

The new tube will operate in the present "standard band" between 60 and 216 megacycles as well as in the UHF channels, which may be assigned as high as 900 megacycles.

Faculty—Prof. Kyle

(Continued from page 34)

gains a personal knowledge of his students which is so valuable in professional placement, and so rare in some colleges and schools.

When not in a classroom or at a foundrymen's convention, Professor Kyle likes to read, or putter around in his garden when the Ithaca weather permits. Summertimes are often spent at his summer home on Lake Winnepesaukee, N. H., where he likes to fish, or just plain rest.

But, when all has been said, a man is judged on the product of his efforts alone and in combination with others. In a few short years, due mainly to the cooperative enterprise of Professor Kyle and his staff, metallurgical engineering at Cornell has grown from a rather small department into a large enterprise. In the future, it bids fair to become even bigger and better; and when it does, much of the credit will undoubtedly fall on the shoulders of the man at the helm, Professor Kyle.

News of the College

(*Continued from page* 16)

Law and business administration have already attracted a few, who feel they can put their technical training to good use outside of the engineering profession.

On May 2 the same seven men held another informal discussion, dealing with the success of the five-year curriculum, at a dinner held in the Willard Straight Memorial Room. The Faculty Curriculum Committees and directors of the various engineering schools were present.

Plastics Laboratory Given

The new William C. Geer Laboratory for rubber and plastics has most of its basic equipment and should be put into operation in the near future. The equipping of this laboratory was made possible by a very generous grant to the University by Dr. William C. Geer, an alumnus of the University, who was formerly vice-president and Director of Research for the B. F. Goodrich Company and who is now engaged in private research work in Ithaca. The laboratory is equipped for both research and instruction in the general fields of plastics and rubber. As work progresses, more equipment will be added to facilitate advanced research.

Soil Moisture

The Civil Aeronautics Administration has just published a report on "The Measurement of Soil Moisture and Density of Neutron and Gamma-ray Scattering" covering work by Professors Sack, Belcher, and Cuykendall. Students working on this program have been Charles Peterson, Bill Jahsman, and Ted Wong. The electron microscope is being used in research under Prof. Siegel in conjunction with a soil identification program being carried on in the C.E. school for the Army. Another use of the microscope is the study of viruses in biological research.

In the graduate school, Ruth Jordan is studying dynamic vibrations in single aluminum and zinc crystals, and Dick Aldrich is doing research in rubber transformations and resulting variations in mechanical properties.

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Articles

Authors

Personalities

STRESS *and* STRAIN...

A drunk staggered into the Club one night and in a loud voice yelled, "'When I drink, everybody drinks!" He summoned everyone to the bar—the musicians, hatcheck girls, waiters, and guests. Everybody took a drink. When he finished his whiskey, he yelled again, "When I take another drink, everybody takes another drink!" Once more everyone gathered around the bar. They even called in the taxi drivers, doormen, and a cop from the corner. When he finished that one, the drunk took a dollar out of his pocket and slapped it on the bar. "When I pay," he screamed, "everybody pays."

* * *

A sports writer was assigned to write a story about the chaplain that always travels with the Notre Dame football team. When he asked the athletic director where he could find the chaplain, the director asked, "Which do you want, the offensive chaplain, or the defensive chaplain?"

* * *

Boss: "I suppose you wish I were dead so you could spit in my grave."

Employee: "Not me. I hate to stand in line."

* * *

The devil sends the blessed winds
To raise the skirts on high;
But God is just—he sends the dust
To blind the wicked eye!

* * *

Sonny: "Pop, what's an optimist?"

Father: "An optimist is a man who thinks his wife has quit smoking cigarettes when he finds cigar stubs in the house."

Three monkeys sat in a cocoanut tree
Discussing things as they're said to be.
Said one to the other, "Now, listen you two.
There's a certain rumor that can't be true,
That man descended from our noble race—
The very idea is a disgrace!"

"No monkey ever deserted his wife,
Starved her babies and ruined her life . . .
And you never knew a mother monk
To leave her babies with others to bunk,
Or pass them on from one to another,
'Til they hardly know who is their mother.

"And another thing you'll never see—
A monk build a fence around a cocoanut tree,
And then let the cocoanuts go to waste . . .
Why, if I put a fence around a tree,
Starvation would force you to steal from me.
"Here's another thing a monk won't do—
Go out at night and get on a stew,
Or use a gun or club or knife
To take some other monkey's life.
Yes, man descended, the ornery cuss,
But, brother, he didn't descend from us!!"

* * *

"Was your friend shocked over the death of his mother-in-law?"

"Shocked; he was electrocuted!"

* * *

Book Salesman: "Young man, you need this book. It will do half your college work for you."

Engineer: "Fine, give me two."

"Well, what excuse have you got for coming home at this hour of the night?"

"Well, my dear, I was playing golf with some friends and . . ."

"What? At 3 a.m.?

"Sure. We were using the night clubs."

* * *

The bus driver charged a lady full fare (10c) for her son. He had on long pants.

At the next corner a small boy wearing short trousers paid only 5c (half fare).

At the next corner a lady mounted the bus and he didn't charge her anything. Why? . . .

You have an evil mind—the lady had a transfer.

* * *

And then there's the man who walked into a bar optimistically and left misty optically.

* * *

Judge: "Give the court your name, occupation and charge against you."

Defendant: "My name is Sparks, I'm an electrician, and I'm charged with battery."

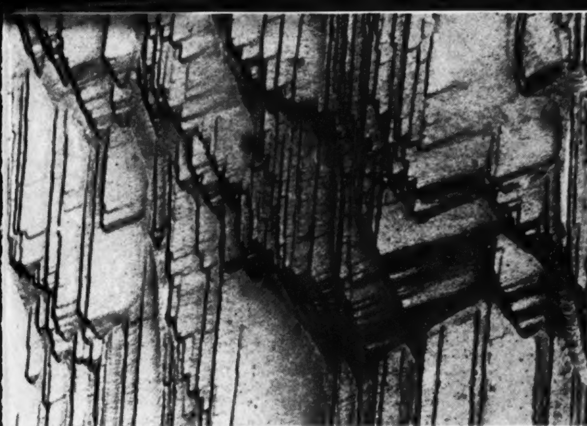
Judge: "Officer, place this man in a dry cell."

* * *

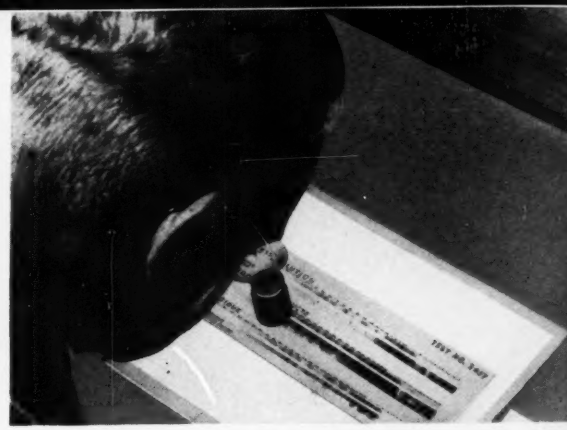
And then there was the engineer who called his girl indefinite integral because she had no limit.

* * *

A young mother had just unburdened herself and told her son the facts of life. At the end she said, "Now if you want to know anything ask me." The boy appeared in serious thought, then gravely turned to his mother and said, "How do they get the Saturday Evening Post out on Wednesday?"

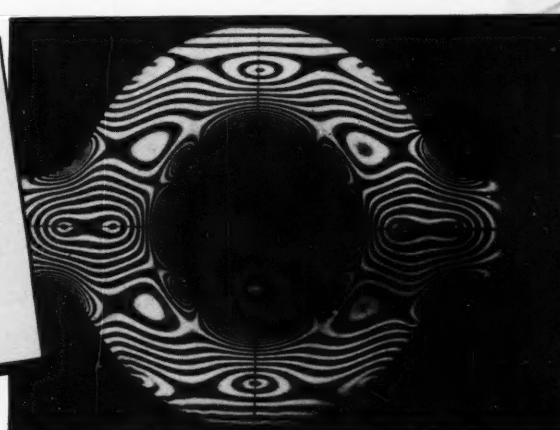


REVEALS NEW FACTS ABOUT METAL STRUCTURE. Electron micrography—up to X50,000 with the electron microscope—reveals new facts about metal structure, surface protection, and effect of processing procedures.



DETERMINES COMPOSITION OF MATERIALS. The composition of almost any material is shown in a flash through spectrography. It is a means of making frequent production line analyses that keep a check on specifications.

Engineering has an ally in photographic analysis



SHOWS STRESSES AND STRAINS VISUALLY. By photographing the patterns developed by polarized light as it passes through a plastic model of a part, the engineer can have visible evidence of the points of stress within the part.

In the engineering laboratory—on the production line—photography is today an important tool. It searches metal structure through electron micrography, x-ray diffraction, and micro-radiography. It makes swift mechanical motions seeable by showing them at a snail's pace with high speed movies. Or it can halt an instant of an instrument's fleeting trace and record it for study.

Eastman Kodak Company, Rochester 4, N. Y.

Send for this FREE Book

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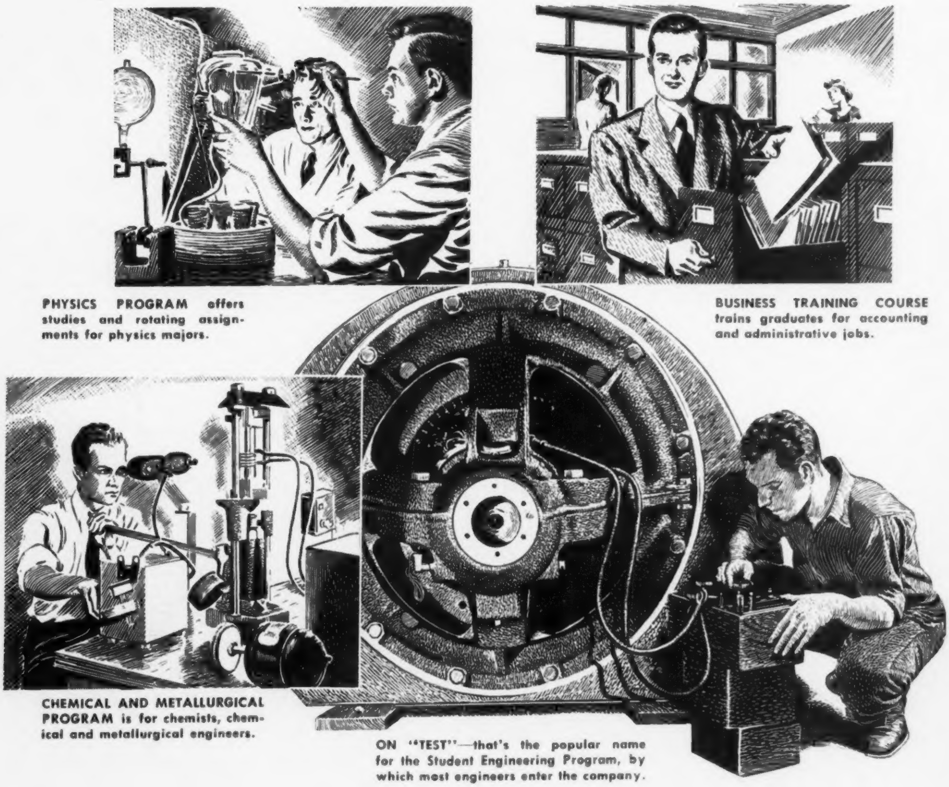

PHYSICS PROGRAM offers studies and rotating assignments for physics majors.

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